



RESEARCH DEPARTMENT

**Long-distance tropospheric propagation
measurements over mixed land
and sea paths at 774 MHz**

RESEARCH REPORT No. RA-14

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**THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION**

RESEARCH DEPARTMENT

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for Head of Research Department

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AND SEA PATHS AT 774 MHz**

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LONG-DISTANCE TROPOSPHERIC PROPAGATION MEASUREMENTS OVER MIXED LAND AND SEA PATHS AT 774 MHz

SUMMARY

Field-strength measurements of a transmission at 774 MHz were carried out over mixed land and sea paths ranging from 196 km to 365 km in length. The results show that the attenuation relative to an all-sea path, introduced by sections of land at the end of the path increases substantially with proportion of land path. The results of the measurements are compared with the values estimated by the recommended CCIR method of calculation for mixed land/sea paths.

At two of the receiving sites the relationship between propagation conditions and the 'height gain' characteristic of the receiving aerial was investigated by concurrent measurements at different aerial heights.

1. INTRODUCTION

During the past decade the BBC has carried out a series of long-distance propagation measurements^{1,2,3,4} over land and sea paths at frequencies (495 and 560 MHz) in Band IV and (774 MHz) in Band V. The results were submitted to the International Radio Consultative Committee (CCIR) and used, in conjunction with data from other United Kingdom and overseas administrations, to derive the separate overland and oversea field-strength/distance curves given in CCIR Recommendation 370-1⁵. These curves are used by broadcasting authorities to assess interference problems of channel sharing.

In addition to estimates involving transmission paths lying entirely over land or over sea, there is an obvious requirement for a method to enable estimates of field-strength to be made for mixed land/sea paths. To supplement the very limited data available pertaining to such paths the BBC (in conjunction with the Netherlands Postal and Telecommunications Service who operated the transmitter at Scheveningen) carried out a series of mixed land/sea path measurements at 560 MHz⁶. As a result of these measurements a method was evolved enabling field strengths over mixed land/sea paths to be estimated from the curves for overland and oversea paths⁷. This method was submitted to the CCIR and is that currently recommended* for mixed land/sea path calculations.

In order to investigate further the validity of the method, the BBC carried out a second series of

measurements over mixed land/sea paths, this time at 774 MHz, and these measurements form the basis of this report. As before, the transmitter was at Scheveningen (Holland), but an alternative series of receiving sites was employed, thereby providing somewhat different transmission paths, which are shown in Fig. 1.

In addition to those measurements yielding data relating field strength to distance and forming the first part of this report, a further series of measurements was carried out at two of the receiving sites. These are discussed in Section 5, and were arranged to investigate the correlation between tropospheric propagation conditions and receiving (or transmitting) aerial height gain i.e. the change of signal with aerial height.

2. TRANSMITTING AND RECEIVING SITES

2.1. Transmitting Site

A Band V transmitter operating at 774 MHz, was installed and operated by the Netherlands Postal and Telecommunications Service at their Scheveningen Radio Station. The transmitter was square-wave modulated at 1 kHz to a depth of 100%, the modulation being cut for two seconds every minute for the purpose of identifying the signal at the receiving sites.

The transmitting aerial was a corner reflector with an intrinsic gain of 13 dB relative to a half-wave dipole, the half-power beamwidth being $\pm 25^\circ$. The aerial was horizontally polarized and at a height of 47 m above ground level (a.g.l.). The direction

* Annex II of CCIR Recommendation 370-1.

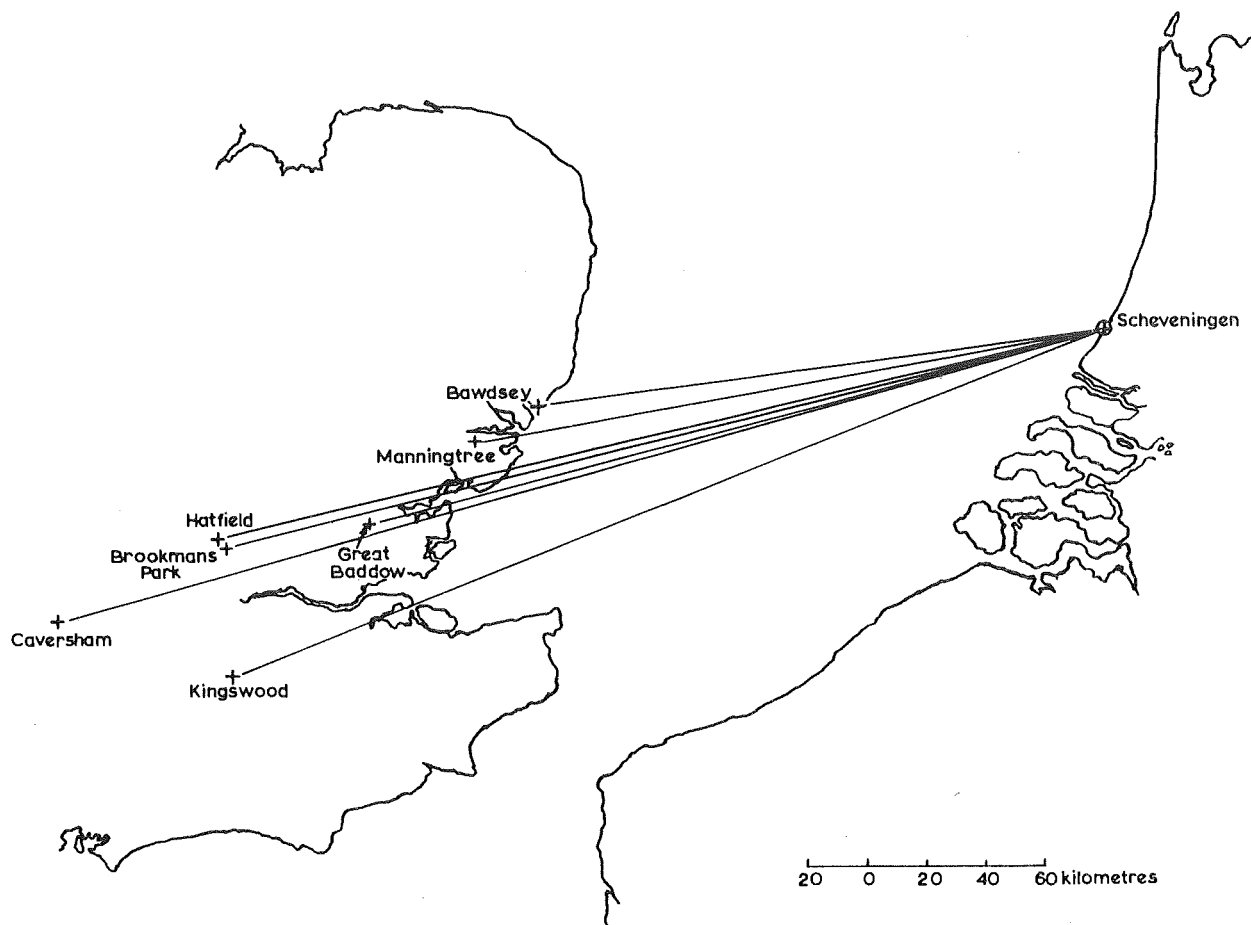


Fig. 1 - Location of sites
 ⊕ Transmitting site + Receiving sites

TABLE 1
 Receiving Site Details

Location	Path distance (km)			Site height a.m.s.l. (m)	Aerial height a.g.l. (m)	Time months	Bearing of transmitter from site ° E.T.N.	Latitude	Longitude
	sea	land	total						
Bawdsey	196	0	196	5	13	April '65 July '67	85	51°59'35" N	1°24'27" E
Bawdsey	196	0	196	5	60	April '65	85	51°59'35" N	1°24'27" E
Bawdsey	196	0	196	5	82	Oct. '65 May '66	85	51°59'35" N	1°24'27" E
Manningtree	205	13	218	36	10	April '65 July '67	84	51°55'20" N	1°05'20" E
Manningtree	205	13	218	36	75	April '65 July '66	84	51°55'20" N	1°05'20" E
Manningtree	205	13	218	36	45	Aug. '66 July '67	84	51°55'20" N	1°05'20" E
Great Baddow	237	25	262	46	12	April '65 July '67	79	51°42'16" N	0°30'7" E
Brookmans Park	205	102	307	128	12	June '66 July '67	80	51°43'40" N	0°10'30" W
Hatfield	210	101	311	76	10	Aug. '65 Sept. '66	81	51°45'0" N	0°14'27" W
Kingswood	254	67	321	167	9	April '65 Nov. '65	72	51°17'20" N	0°12'50" W
Kingswood	254	67	321	167	15	Sept. '65 July '66	72	51°17'20" N	0°12'50" W
Caversham	230	135	365	82	12	April '65 Sept. '65	77	51°28'48" N	0°57'23" W

of maximum radiation was 260° East of True North, giving in this direction an effective radiated power (e.r.p.) of 0.6 kW. The site height was 13 m above mean sea level and for all transmission paths the radio horizon was the sea.

The daily schedule of transmission was 0700 to 2300 hrs. G.M.T.

2.2. Receiving Sites

The coastal site, which may be considered as the reference site, was at the R.A.F. Station Bawdsey (Suffolk); the inland sites were at Manningtree and Great Baddow (Essex), Hatfield and Brookmans Park (Herts), Kingswood (Surrey) and Caversham (Oxon). Fig. 1 shows the location of the receiving sites and Table 1 gives additional details. The land and sea constituents of the path Scheveningen - Great Baddow must be considered as approximate. This path traverses the whole length of the Blackwater Estuary and the land/sea boundary is thus somewhat indeterminate.

The type of u.h.f. receiver used for the measurements has been described elsewhere⁸. The type of aerial used at all sites was a 10-element Yagi having an intrinsic gain of 10 dB relative to a dipole. A subsidiary experiment to investigate receiving aerial height gain was carried out at both Bawdsey and Manningtree. Due to the considerable feeder attenuation at these sites the aerials were provided with transistorized pre-amplifiers of 10 dB gain.

Recorder charts were run at a speed of 76 mm (3 in.) per hour.

3. RESULTS

3.1. Analysis

The records of the measurements for each transmission path were analysed to determine the length of time during which the signals exceeded various levels of field strength. These time durations, expressed as percentages of the overall valid recording time, were then plotted against field strength in decibels relative to $1\mu\text{V/m}$ [dB($\mu\text{V/m}$)] for an e.r.p. of 1 kW.

3.2. Variation of Field Strength with Time

Fig. 2 gives the results of the analysis for each of the receiving sites (excluding the results for the greater receiving aerial heights at Bawdsey and Manningtree, which are discussed in a later section). No curve is available for the Caversham site since no signal in excess of receiver noise level (approximately 12 dB ($\mu\text{V/m}$) for 1 kW e.r.p.) was received during 5½ months of recording.

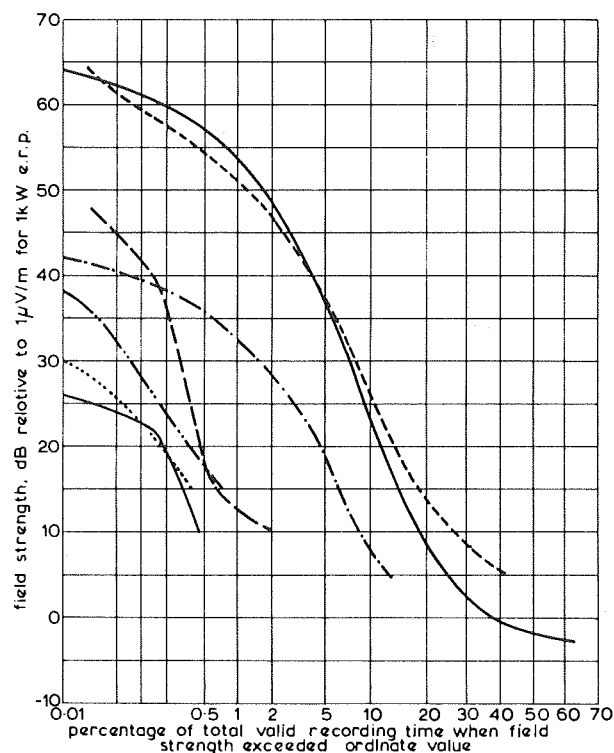


Fig. 2 - Field-strength distributions at the different receiving sites

—————	Bawdsey
-----	Manningtree
- · - · -	Great Baddow
-----	Brookmans Park
.....	Hatfield
— · — · —	Kingswood [aerial at 15 m (49 ft) a.g.l.]
— × — × —	Kingswood [aerial at 9 m (30 ft) a.g.l.]

Field strengths exceeded for specified time percentages, namely 0.1%, 1%, 5%, 10% and 50%, were extracted from Fig. 2 and are given in Table 2. Also given in this table are the values of free-space field strength appropriate to the various transmission path lengths. It should be noted that not all the recording periods were of equal length, or concurrent. This should be borne in mind when comparing the various distributions.

A feature which is immediately apparent from Fig. 2 and Table 2 is that, with the exception of the three sites nearest to the coast*, signal was only recorded for a very small percentage of time, e.g., less than 0.5% time both at Hatfield and at Kingswood (for the 9 m a.g.l. aerial condition).

3.3. Receiving Site Variation Factor

3.3.1. General

Receiving sites are not always representative of the areas in which they are situated, whereas the CCIR field-strength/distance curves

* The minimum measurable levels of field strength at the other sites were in the range 12 ± 2 dB ($\mu\text{V/m}$) for 1 kW e.r.p.

'apply to 50% of receiving locations in the rolling irregular terrain found in many parts of Europe and North America'. Consequently, if the measured results of Table 2 are to be compared with the estimated values obtained from the CCIR curves it is important that an appropriate site variation factor (s.v.f.) correction be applied to refer the individual sites to those representative of 50% locations.

In previous propagation experiments carried out by the BBC Research Department the practice has been, where possible, to determine the s.v.f. correction by making field-strength measurements at a number of locations within some 10 km of the fixed site and comparing the results at these locations to the corresponding field strength at the fixed site for the same period of time. In this mixed land/sea path experiment this method of determining s.v.f.'s was unsuitable for the following reasons:-

- (i) At Kingswood, Hatfield and Brookmans Park, signal was received so rarely that it was not practicable to make comparative measurements in this manner.
- (ii) At the inland sites close to the coast (Manningtree and Great Baddow), the length of land path is so small that extreme care would have had to be taken to ensure that the temporary locations were comparable to the fixed site in terms of land path length. If this requirement was fulfilled it would then be difficult to ensure that they were still a representative selection of locations.
- (iii) Evidence has accrued from the results of previous s.v.f. measurements to indicate that any measured s.v.f. correction may only be applicable to the particular propagation conditions occurring at the time of the measurement. (This is also suggested by the height gain measurements described in a later section.)

In view of the difficulties inherent in obtaining valid s.v.f. measurements, corrections for all sites except Bawdsey are estimated on the basis of a method used by the BBC in co-channel interference calculations⁹. This relates to the calculation of field strength at individual receiving locations. The correction factor so obtained is expressed as a function of the elevation of the horizon from the receiving aerial in the direction of the transmitter. The empirical curve relating correction (in decibels) to horizon angle was derived from an analysis of measurements at a great number of receiving locations within the service area of u.h.f. transmitters. The corrections applicable to the various receiving sites used in this investigation are given in Table 3; they have the effect of normalizing the measurements to those for a site having the horizon in the same horizontal plane as the aerial. Where trees form an obstruction in the immediate vicinity of the receiving aerial, as in the case of the Bawdsey, Kingswood and Caversham receiving sites, a further correction factor is required. Unfortunately at Kingswood and Caversham no value could be ascertained for this further correction.

Two further factors arising from the measurements and relating to site variations are:-

- (i) The Hatfield and Brookmans Park sites lie within 5 km of each other, the former in a shallow valley with ground on the transmitter bearing rising to a densely wooded ridge some 20 m higher than the receiving aerial at a distance of 1½ km, and with houses on an intervening ridge forming an additional diffraction zone. Brookmans Park is situated on a plateau with the ground level falling gently towards the transmitter. During the period for which receivers were simultaneously in operation at the two sites it was found that the ratio of the signal levels received was approximately 20 dB,

Receiving site	Receiving aerial height a.g.l. (m)	Field strength exceeded for specified time percentage [dB(μV/m) for 1 kW e.r.p.]					Free-space field strength [dB(μV/m) for 1 kW e.r.p.]
		0.1%	1%	5%	10%	50%	
Bawdsey	15	61.0	53.5	37.5	23.0	-1.5	61.0
Manningtree	10	59.5	51.5	36.5	24.0	4.0*	60.2
Great Baddow	12	39.5	32.5	19.0	8.5	-	58.6
Brookmans Park	12	42.0	13.0	-	-	-	57.2
Hatfield	10	22.5	-	-	-	-	57.1
Kingswood	9	22.5	-	-	-	-	56.8
Kingswood	15	28.0	13.0*	-	-	-	56.8
Caversham	12	No signal recorded. Receiver noise level: 12 dB(μV/m)					55.7

* Extrapolated value

TABLE 2
Results of Measurements

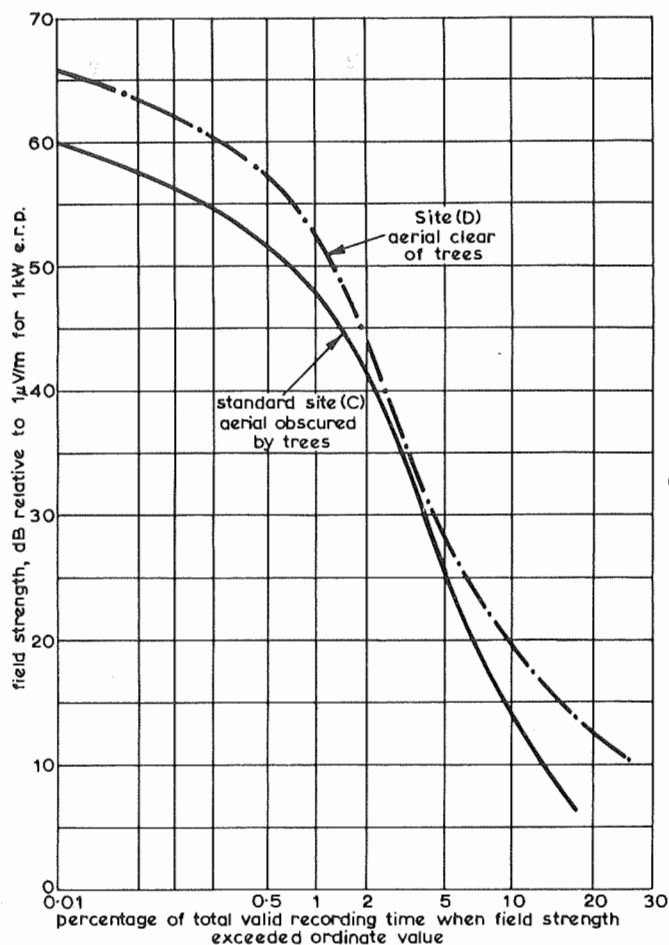
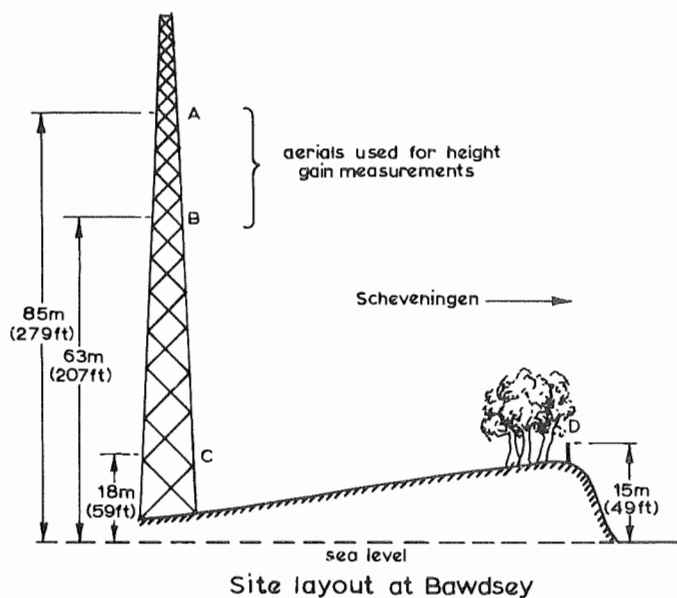


Fig. 3 - Determination of loss due to trees at the Bawdsey site



attributable to the differing path profiles. This ratio is somewhat greater than that of Table 3 (14.5 dB), but the values in the Table take no account of the trees or houses obscuring the Hatfield profile.

- (ii) The receiving site at Kingswood is surrounded by trees of heights up to 25 m. The considerable attenuation induced by these trees is indicated by comparison of simultaneous measurements at the receiving aerial heights of 9 m a.g.l. and 15 m a.g.l., which showed the field strength at the latter height to be some 18 dB greater than at the former height.

3.3.2. Site Variation Factor at Bawdsey

The concept of s.v.f. at coastal sites is somewhat different to that for inland sites. The average location represented in the CCIR overseas curves is assumed to be situated in a built-up coastal strip, such that a 'clutter' loss of approximately 7 dB occurs, i.e. the field strength is 7 dB

less than that for a receiving aerial some 10 m a.g.l. on an open low site at the coast¹⁰.

The topography of the Bawdsey site is as shown in the sketch of Fig. 3. From this it will be seen that the reference aerial (the lowest aerial on the tower), is obstructed by trees. To assess the attenuation due to these trees an aerial was mounted at a comparable height on the seaward side of the trees, and simultaneous recordings made of the field strength received at the two aerials. The field-strength/time-percentage distributions so obtained are also represented in Fig. 3.

It may be seen that the ratio between the field strengths appears to vary with time percentage, i.e. with propagation conditions, but for the purpose of estimating the s.v.f. correction it is assumed that the attenuation due to the trees is 5 dB for all time percentages. Since the CCIR curves for overseas paths include a 'clutter' loss of 7 dB the appropriate correction required to standardize the distribution of Fig. 2 for comparison with the CCIR curves is -2 dB.

TABLE 3

Comparison of Measured and Estimated Results

Receiving site	S.V.F. correction (dB)	Measured field strength exceeded for specified time percentage [dB(μ V/m) for 1 kW e.r.p.] Corrected for s.v.f.				Estimated field strength exceeded for specified time percentage [dB(μ V/m) for 1 kW e.r.p.] CCIR mixed path method			
		1%	5%	10%	50%	1%	5%	10%	50%
Bawdsey	-2 ^x	51.5	35.5	21.0	-3.5	56.5	33.0	21.0	-3.0
Manningtree	-6	45.5	30.5	18.0	-2.0*	45.5	28.0	17.0	-7
Great Baddow	+0.5	33.0	19.5	9.0	-	34.0	19.0	9.0	-
Brookmans Park	-6.5	6.5	-	-	-	19.0	6.0	-	-
Hatfield	+8 [†]	<NL(14dB)	-	-	-	19.0	6.0	-	-
Kingswood (9 m)	+2 [†]	<NL(10dB)	-	-	-	22.5	7.0	-	-
Kingswood (15 m)	0 [†]	13.0*	-	-	-	22.5	7.0	-	-
Caversham	-6 [†]	<NL(12dB)	-	-	-	13.5	-	-	-

^x See Section 3.3.2. * Extrapolated † No allowance made for effect of trees

4. COMPARISON OF MEASURED AND ESTIMATED RESULTS

In Table 3 are given the s.v.f. corrections derived as described in the previous Section; also given are the corrected values of field strength exceeded for 1%, 5%, 10% and 50% time, derived from Table 2. For comparison Table 3 shows the values of field strength estimated from the CCIR land and sea curves by the currently proposed method for mixed land/sea path calculations⁷. Since there is no CCIR curve for 5% time over land paths the appropriate values have been interpolated from the 1% and 10% curves, assuming a log-normal variation of field strength with time.

A feature which is obvious from a comparison of the measured and estimated values is that whereas agreement is very good for the three sites with the smallest component of land path (Bawdsey, Manningtree and Great Baddow), it is poor for the remaining sites, the measured values being substantially less than the estimated values. Whilst it is realized that the corrections applied to the measurements are empirically derived and subject to a wide margin of tolerance, it is felt that the differences between the measured and estimated values for the inland sites are too great to be explained by possible inaccuracies in the corrections.

5. TEMPORAL CHARACTERISTICS OF ABNORMAL PROPAGATION

In view of the considerable discrepancy between measured and estimated values of field strength at

the inland sites, it is appropriate to consider the differing characteristics of abnormal tropospheric propagation over land, sea and mixed land/sea paths. It has been demonstrated in an earlier report¹¹ that the times of occurrence of high signal levels over land paths are, except in winter, generally confined to the early morning and late evening periods of the normal daily transmission schedule. Over sea paths no such diurnal effects are apparent but seasonal effects are pronounced, the majority of periods of abnormal propagation occurring in the summer months. It follows therefore, that over a mixed land/sea path (for which both land and sea components are of a considerable length) periods of high field strength may be expected to be confined to those times for which propagation conditions are favourable over both land and sea. Consequently the periods of high signal level may be expected to be confined to the morning and evening periods of the summer months.

To test this hypothesis the results of the measurements over the Scheveningen to Brookmans Park path were examined to determine the times of occurrence of field strength exceeding receiver noise level. For the purpose of this investigation recordings of Scheveningen at Brookmans Park (and at Great Baddow) were continued for a further two months after the completion of the main measurement programme in July 1967. The diagram presented in Fig. 4(a) shows the periods for which measurable signal radiated from Scheveningen was received at Brookmans Park from the time of installation of the equipment on 14th June 1966 until 30th September 1967. In Fig. 4(b) are plotted the times of occurrence of high field strengths over the path Scheveningen to Great Baddow, which for the

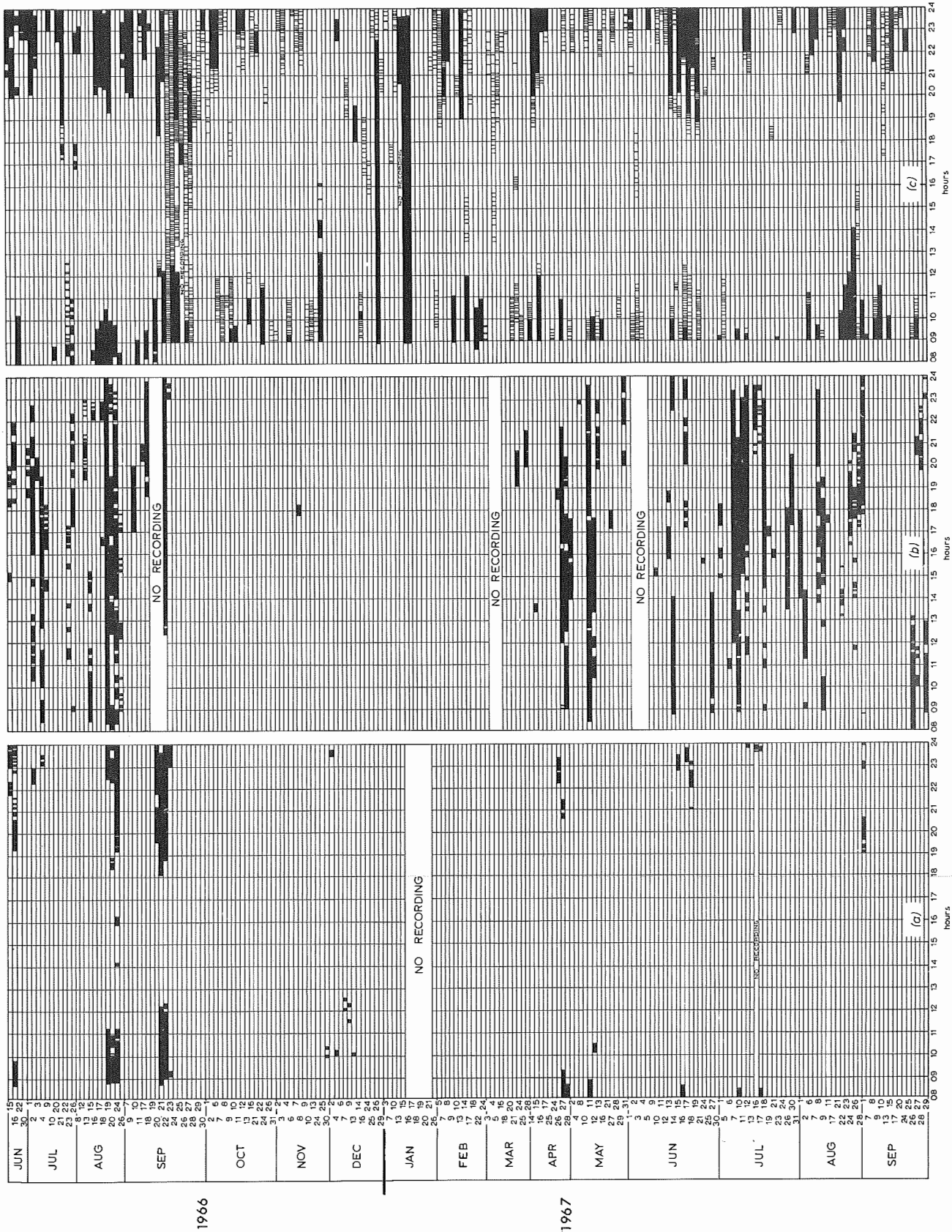


Fig. 4 - Times of occurrence of exceptional propagation conditions for overland, overseas and mixed land/sea transmission paths, 14th June 1966 - 30th Sept. 1967

- (a) Schevevingen - Brookmans Park Mixed Land/Sea Path
 (b) Schevevingen - Great Baddow 'Seed' Path
 (c) 14th June - 20th Sept. 1966 Crystal Palace - Tacolneston
 20th Sept. 1966 - 30th Sept. 1967 Sutton Coldfield - Brookmans Park Land Paths

purpose of this comparison may be considered to represent a sea path. In order to indicate the equivalent times of occurrence of abnormal propagation over an all-land path in this area, the results of concurrent measurements made at Brookmans Park of the transmission from Sutton Coldfield (629.25 MHz) are plotted in Fig. 4(c)*. The limit of field strength represented in Figs. 4(b) and (c) is arbitrarily chosen as that exceeded for 5% of the total period of the respective measurement programmes (i.e. April 1965 to July 1967 at Great Baddow, September 1966 to September 1967 for the path from Sutton Coldfield to Brookmans Park). Where the received field strength has never exceeded the specified level during a day on any of the three transmission paths the line for that day is omitted from the diagram.

Fig. 4(b) clearly shows that over the period investigated times of abnormal propagation over sea are confined to the summer months. Likewise Fig. 4(c) shows that over the land paths such periods are (except in autumn and winter) generally confined

* Sutton Coldfield measurements commenced on 20th September 1966. Prior to this, corresponding results of measurements of Crystal Palace (573.25 MHz) at Tacolneston (Norfolk) were utilized. This transmission path (147 km long) intersects the path from Scheveningen to Brookmans Park.

to early morning and late evening. As might be expected the corresponding periods over the mixed land/sea path are confined to times for which both conditions are satisfied, i.e. mornings and evenings in the summer months. This restriction of the time favourable for abnormal propagation may well be the reason for the discrepancy between measured and predicted results but further work is required to determine whether this is so.

6. HEIGHT GAIN MEASUREMENTS AT BAWDSEY AND MANNINGTREE

6.1. General

The CCIR curves of Recommendation 370-1 use the effective height of the transmitting aerial as a parameter, thereby introducing the concept of transmitting, (and by reciprocity, receiving) aerial 'height gain'. The measurements upon which the overland curves were based were normalized for an effective aerial height of 300 m a.g.l.¹⁰. Curves for other heights were developed by assuming that the field strength depends only on the distance between horizons, i.e. the field strength at distance X km from a transmitting aerial of height h_1 (in metres) is the same as for a transmitting aerial of height 300 m at a distance $(X + 70 - 4.1\sqrt{h_1})$ km.

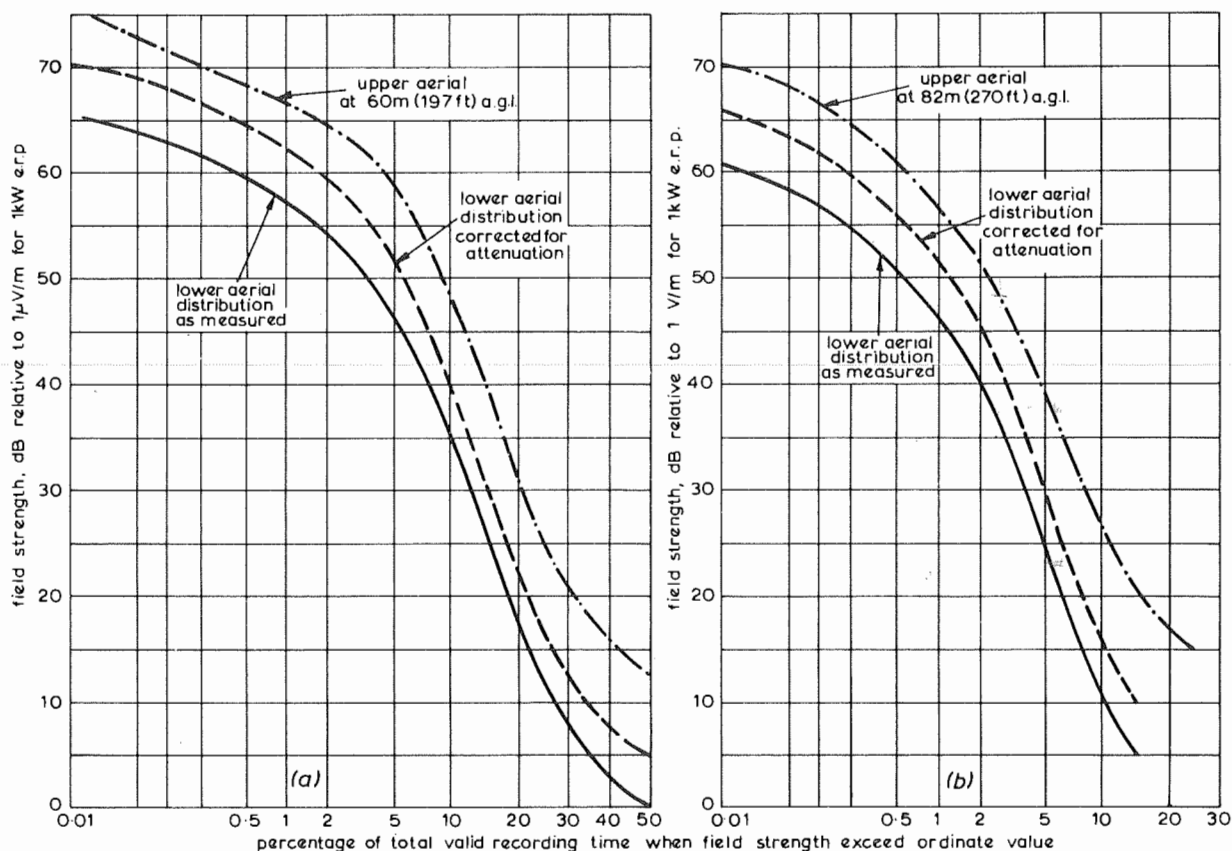


Fig. 5 - Field-strength distributions for height gain measurements at Bawdsey

This assumption is also used in the derivation of the overseas curves for 10% and 50% time, but it is assumed that the effect of height gain is negligible beyond the horizon for 1% time. The 5% curve which is an interpolation of the 1% and 10% curves contains approximately half the height correction.

In order to check some of these assumptions regarding height gain (and assuming the principle of reciprocity to apply) concurrent measurements were made at different receiving aerial heights at both Bawdsey and Manningtree.

6.2. Results

The various heights of the receiving aerals used at Bawdsey and Manningtree are detailed in Table 1. At each site recordings at the lowest aerial height were carried out throughout the total period of the experiment and the analysis of these results is as represented in Fig. 2 and Table 2. Additionally, for the periods indicated in Table 1, field strength recordings were concurrently made at greater aerial heights on each mast. These recordings were also analysed by the method described in

Section 3.1, the results of the analyses for the concurrent measurements at the two aerial heights being shown in Fig. 5(a) and 5(b) (Bawdsey) and Fig. 6(a) and 6(b) (Manningtree). Also shown on Fig. 5(a) and 5(b) are the equivalent distributions for the appropriate period at the lower aerial height in the absence of attenuation due to trees, based on an assumption of a constant 5 dB loss (as discussed in Section 3.3.2).

Comparison of the lower aerial distributions of Fig. 5(a) and 5(b), which were made over different periods of time, shows these to be significantly different from each other, and from the distribution for the more prolonged period represented in Fig. 2. This implies that the shorter periods of measurements were not long enough to cover a representative sample of propagation conditions. For this reason it seems more appropriate, when relating height gain to type of propagation condition, to treat the actual value of field strength exceeded, rather than time percentage, as the parameter for comparison. The results of Fig. 6(a) and 6(b) are similarly treated, although in this instance the differences between the results for the two periods of time are not so pronounced.

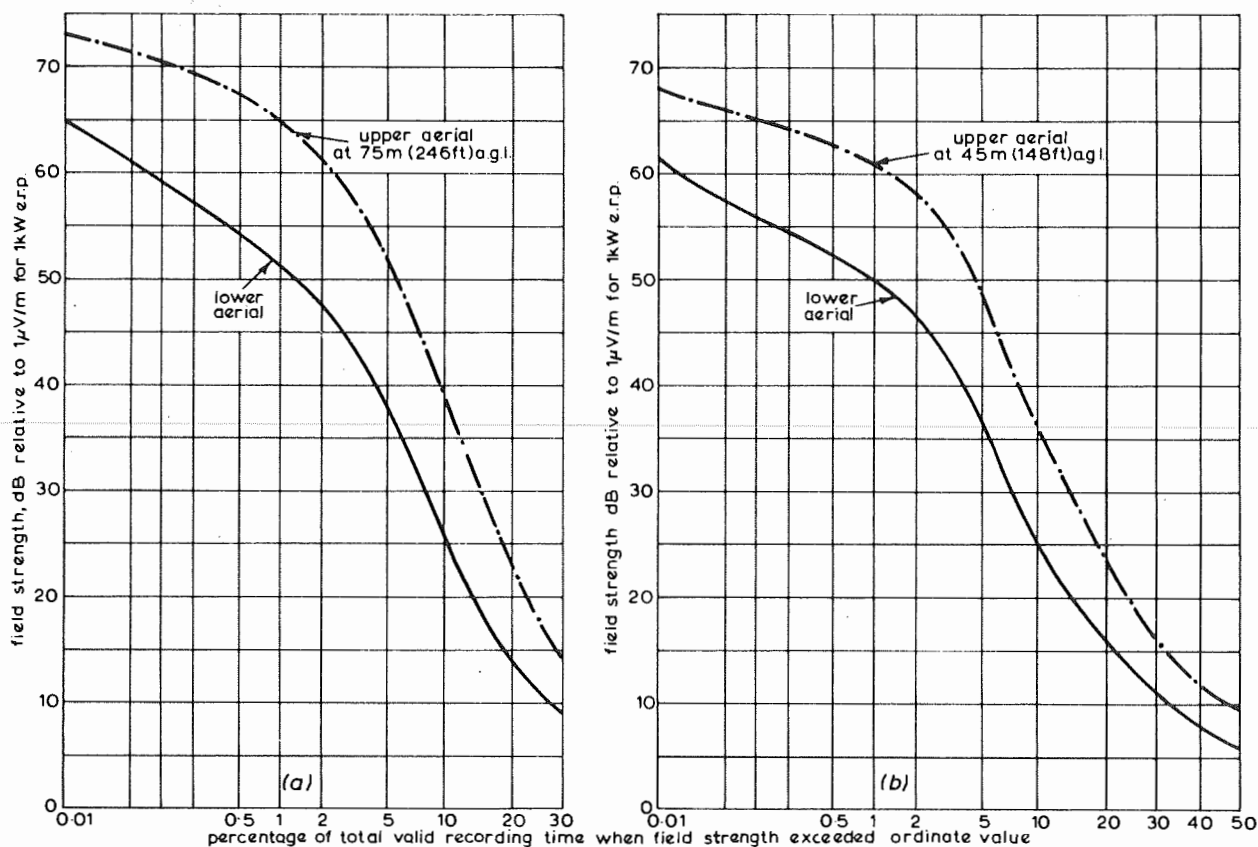


Fig. 6 - Field-strength distributions for height gain measurements at Manningtree

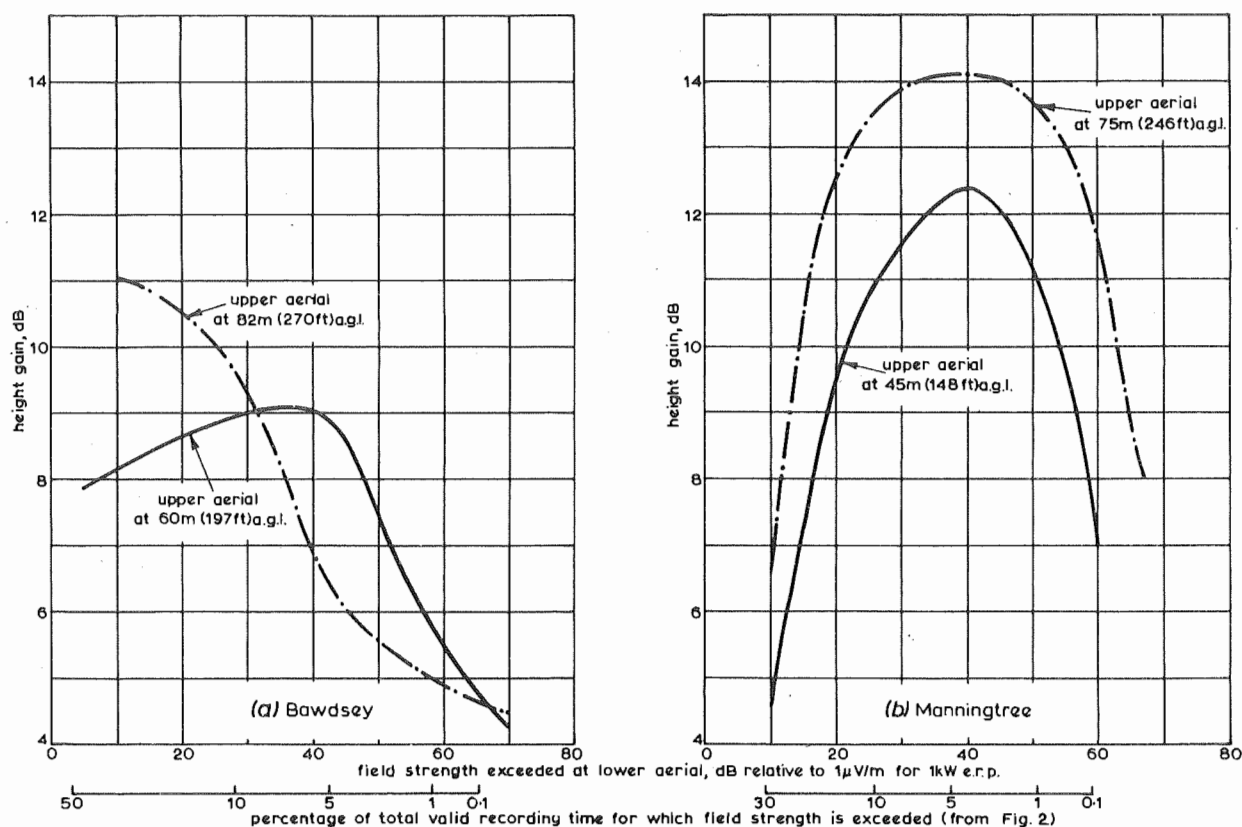


Fig. 7 - Receiving aerial height gains at Bawdsey and Manningtree
(Expressed relative to lower aerial as reference)

Fig. 7(a) and 7(b) represent the height gains obtained at Bawdsey and at Manningtree respectively, expressed in terms of the field strength exceeded at the lower aerial, (amended in the case of Bawdsey by 5 dB to refer the datum to that of an aerial unobstructed by trees). A subsidiary abscissa scale relates these values of field strength to time percentage and is derived from the distributions for the overall recording period represented in Fig. 2.

6.3. Discussion of Height Gain Measurements

6.3.1. Bawdsey Measurements

The results represented in Fig. 7(a) show that, as assumed in the CCIR overseas curves, height gain appears to be progressively reduced as propagation conditions become more abnormal. It is not thought that any significance should be attached to the fact that the two curves cross over, this type of discrepancy being within the tolerance of the measurement accuracy obtainable, particularly in view of the assumption made in referring the lower aerial measurements to those for an unobstructed aerial. Averaging the two curves and assuming this average to apply to the height gain to be expected between an aerial at 15 m a.g.l. and one

at 75 m a.g.l. we have:-

Time Percentage:	1%	5%	10%	50%
Height gain (dB):	5	8	9.5	9.5

Thus it would appear that, although the height gain corresponding to propagation conditions representative of 1% time is only half that for time percentages of 10% and above, it should not be considered as being negligible.

When seeking to extrapolate the series of CCIR curves to aerial heights less than 37.5 m, the method proposed in Report 239 (i.e. by use of the formula $(X + 70 - 4.1\sqrt{h_1})$, will indicate little height gain for any but short path lengths. For example by reducing h_1 from 37.5 m to 15 m the increase in effective path length is only about 10 km, which for a path length of 200 km corresponds to a change in field strength of only about 1 dB. It should, however, be emphasized that the measured results depend upon the assumption of a constant loss of 5 dB due to the trees. Fig. 3 appears to show attenuation increasing under normal conditions, and this would have the effect of reducing the height gain values referred to the unobstructed aerial.

6.3.2. Manningtree Measurements

The results represented in Fig. 7(b) are somewhat surprising in that they show maximum height gains for propagation conditions corresponding to approximately 5% time. The decrease of height gain as conditions become more abnormal, (i.e. for small time percentages), is as expected for an oversea path, and as obtained at Bawdsey. The reason for the decrease of height gain as conditions also become more normal (i.e. for greater time percentages), is not known. It should, however, be noted from Table 3 that the measured field strength at Manningtree for 50% time at an aerial height of 10 m a.g.l. (which is extrapolated), is the only value for this site that is not in good agreement with the CCIR estimate. This implies that the anomaly lies in the exceptionally high values measured at the lower aerial under normal propagation conditions.

For comparison between the measured height gains at this site and the values derived from the CCIR curves it is appropriate to consider aerial heights above mean terrain (a.m.t.) rather than above ground level (a.g.l.). The site height at Manningtree is approximately 25 m above mean terrain (3 to 15 km). Values of height gain derived from the CCIR land (or sea) curves for aerial-height increases from 10 m to 45 m a.g.l. (35 m to 70 m a.m.t.) and from 10 m to 75 m a.g.l. (35 m to 100 m a.m.t.) have maximum values of approximately 1.5 dB and 2.5 dB respectively, over this path length. The measured values are considerably in excess of this (as shown in Fig. 7(b)), and a possible reason for this discrepancy is that for all aerial heights in excess of about 30 m a.g.l. the sea forms the radio horizon. In this circumstance it is probably more appropriate, when estimating field-strength values, to treat the path as if it were entirely over sea.

7. CONCLUSIONS

The results of the mixed land/sea measurements described in the first part of this report indicate that the measured field strengths are in good agreement with the values calculated from the CCIR curves by the currently proposed mixed land/sea path method, provided that the proportion of land path is small. For greater proportions of land the agreement is poor, the measured values being substantially less than the calculated values. The discrepancy is greater than could reasonably be attributed to errors in correcting the measurements by the site variation factors. A possible explanation of this anomaly is suggested, based upon the differing temporal characteristics of abnormal propagation over land and sea paths. However, further work is urgently needed to assess the validity of this explanation.

The results of the measurements of height gain at low aerial heights carried out at Bawdsey (coastal site) and Manningtree (13 km inland) indicate a reduction of height gain as propagation conditions become very abnormal (i.e. with decreasing time percentage from a value of approximately 5% time). At both sites, and for time percentages other than normal propagation at Manningtree, the measured height gains are in excess of those estimated from the CCIR curves. In particular, the value obtained for 1% time at Bawdsey cannot be considered negligible as assumed in the current 1% CCIR oversea curves. The large height gains measured at Manningtree may be related to the change of radio horizon from land (with aerial at 10 m a.g.l.), to sea (at heights in excess of 30 m a.g.l.). The explanation of the 'parabolic' shape of the height gain vs. field-strength curve of Fig. 7(b) is not known and must be assumed to be due to the overlapping effects of more than one mode of propagation.

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